PERIPHERAL VISUAL AWARENESS:

The Central Issue

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Abstract

Peripheral visual awareness is a greatly overlooked resource in the overall scheme of visual performance. Although there seems to be little or no education, research, nor concern for this aspect of visual function, peripheral vision may be much more important than many involved in vision care are acknowledging. With the absence of attention to the importance of peripheral visual function, it is possible that undesirable, unnecessary limitations are manifested in the care provided. This may not be limited to those in need of vision therapy, but may be an important factor in almost all levels of vision care.

Key Words

peripheral visual awareness, central vision, distribution of light, spatial orientation, context, stress, survival, visually-guided behavior

Peripheral vision may well be the most important aspect of the visual process although it is usually not formally evaluated in a standard eye exam. That is, if by visual process we mean a dynamic transformation involving an input of radiant energy from the environment followed by the processing of this input to information and completed by some type of response (be it thought and/or action). Peripheral visual awareness will be considered as the ability to be cognizant of, though not distracted by, a significant amount of space/time volume relative to the particular setting and task at hand. Many eye care providers view the visual process as the ability to recognize a common symbol of a certain size at a given distance and, therefore, view the periphery as important only within the context of glaucoma and other physiological disease processes. Consequently, peripheral awareness is not considered to be an issue although it is intimately linked with many aspects of visual performance as well as survival mechanisms at the most fundamental levels of our nervous systems. It is also closely related to systems involved with balance, movement, stress and relationships.[1,2,3]

It is well accepted that 20% of the fibers that make up the optic nerve go directly to so-called lower (postural) centers in the brain rather than to visual centers, as do the other 80%.[4] However, those 20% represent up to 80% of the area of the retina —the peripheral retina. Apparently a large amount of visual information has little to do with "seeing" per se, but very much to do with being. Since there is no evidence that an actual image is formed on the retina, or anywhere else for that matter,[5] more of our attention should be directed toward the distribution of light entering the eye and striking the retina as a core issue. Since incoming light (energy/information) does not selectively seek the fovea, the peripheral retina is continuously processing the bulk of this input. To put this another way, if the distribution of light is taken as a whole, as it spreads out over the entire retina, as opposed to isolating our scrutiny toward the macular events, it is clear that there is much more overall action taking place throughout the peripheral retina. As with all human mechanisms and processes, there is a reason and a purpose to this. Such reason and purpose usually result from necessity, which, in the case of sensory mechanisms, usually refers to survival. If so much of the retinal neuro-anatomy is dedicated to this blurry, color-deficient way of seeing,[6] (p.506) there must be something else important going on. Since the vast majority of the area of the retina is considered peripheral by definition, it is curious that this same portion of the visual apparatus and function is totally ignored by virtually all investigators except behaviorally oriented optometrists.

Thus, despite the fact that most incoming light is processed by peripheral retina and not by fovea, it is the nature of our culture that emphasis is placed on the small details, not the big picture; on outcome, not process; on stasis, not change. Central/foveal vision is about static details and outcome. Peripheral vision is about movement and process, and it is involved with detecting and understanding the big pic-

ture—the context and changes in our environment. It represents the bulk of what our world demands that we process visually. We can use it well, poorly, or apparently, not at all. At least visually speaking, it helps to keep us in touch with our relationship to everything with which we share visual space. Peripheral vision is at the heart of awareness of, and response to, the total space/time volume of our visual environment and all its inhabitants. Without the involvement and guidance of peripheral awareness the fovea would, for the most part, be "lost in space," not knowing where to turn. This is exemplified by individuals suffering from pathological field losses, such as those seen with late-stage glaucoma or retinitis pigmentosa.[6] (p.506) In such cases the central acuity may remain intact but, as the peripheral fields shrink, mobility becomes more and more difficult.

Many cases show that with functional (and therefore reversible) deficits, similar problems arise for individuals who have inefficient peripheral awareness; whenever something enters into their awareness it draws their total attention. It becomes the center of attention because these people function primarily within a small central field.[7,8] There is little or no control over the periphery so that objects and people of certain stimulus parameters that enter this area appear suddenly, as a surprise, and therefore a curiosity or a possible threat. This may also contribute to attention problems because, without sufficient peripheral awareness, the context of visual space is lost and it becomes difficult to distinguish figure from ground.[9] The environment becomes a series of unconnected, unrelated details to be dealt with one at a time—the background is practically non-existent. A detail tends to manifest its true importance only as part of something larger and more complex. It only has meaning within a context. Peripheral awareness provides the context for visually-guided behavior.

Measurements and Manifestations

Many eye care professionals believe that unless there is some type of pathology, visual fields will exhibit normal measurements and function. However, they overlook the fact that, potentially, many otherwise healthy eyes/individuals will reveal significant functional constrictions of the visual fields as measured by kinetic perimetry. When the visual system is functioning inefficiently and is, therefore, under stress, this will often be reflected in kinetic perimetry findings. The measurement process is similar to a tangent screen, except that is done in an instrument. I am currently using an AO Stereo Campimeter, which has the same optical set-up as a Brewster Stereoscope.[10] Newer devices which have no optical components are available. (I have not yet been able to compare these kinetically measured findings with the current state-of-the-art static perimeters.) It is not uncommon for these individuals to show constricted fields measuring 10 to 20 degrees in diameter, or less. I have found that the shapes of these fields are often quite irregular. Another interesting finding is enlargement of the blind spot which can be severe in some cases. There will typically be a significant inequality between the two monocular fields which I interpret as an indicator of the current level of binocular interaction. That these findings are meaningful with respect to a person's behavior and visual performance, and are non-pathological, is brought out by the fact that, in my experience, over the course of vision training the fields will rapidly and greatly increase while the blind spots will simultaneously reduce to normal size. Irregularly shaped fields will become more rounded.

Peripheral Vision and Stress and Survival

Peripheral vision is intimately related to the brain stem areas that control vital functions such as blood pressure, heart rate, respiration, etc.[3] It is a survival mechanism, letting us know whether or not our surroundings are threatening to us. Stressful situations arouse the sympathetic nervous system which, among other things, causes dilation of the pupils. This allows for more light to enter and reach a greater area of the retina, which may provide a wider range of information about the environment. If peripheral awareness is at a desirable level of functioning in the first place, two things may occur. First, there will be fewer stressful events since there will be fewer surprises in the environment; and second, the ability to react to and make closure (an acceptable conclusion) with such events will be more efficient.

As Selye[11] observed, and is now widely accepted, stress in itself is not a bad thing. It is the response to stress that can be toxic. Stress creates changes in body chemistry as well as basic functions such as respiration, heart rate, blood flow, etc. If the response to a stressful event includes closure, all systems will return to normal. Without closure, the stress response persists. Humans depend heavily on vision to determine the status of the surroundings. When there is insufficient information readily available, stress levels are high.[12] If this is a chronic condition, the stress response may never cease, creating psychological and physiological damage. Not knowing that possible threats are nearby may even be more stressful than a direct stressful confrontation.

Evolution gives us some insight into the importance and development of organisms and their structures. The earliest organs of "sight" were used to initiate responses based on the organism's orientation in relation to light (the sun). As the complexity of organisms increased, this function expanded to include information about orientation of self—that is, the relationship to gravity. Knowing where the light is gives information about body orientation and spatial orientation within the environment. The retinal fibers that terminate in the superior colliculus seem "to be without any derivatives from the more recently developed macula and have no cortical projection. The fibres which run to it, however, are undoubtedly the most primitive phylogenetically and represent the survivors of practically the whole of the afferent visual fibres to the tectum of the lower animals, and there is little doubt that in man they are associated with the primitive photostatic rather than the higher sensory functions of vision."[4] (p.248) The retina, via some M (magno) cells, projects to the colliculus. P (parvo) cells do not project to the colliculus, leaving it color-blind. Many of these neurons are selective for movement. They are very responsive to small stimuli, with little interest in the details of the stimulus. This is an early warning system, projecting to the superior colliculus, and is the main visual system in lower vertebrates. In mammals, many of its functions are handled by the neocortex. It is mainly concerned with eye movements and other aspects of visual attention and integrates with auditory and somatosensory input.[5] (p.125-7)

Retinal neuroanatomy gives another clue as to the importance of peripheral

function. The overall ratio of rods to cones is 17:1, with a concentration of rods in the near periphery equaling that of the cones in the foveola (150,000/mm2).[6,13] Fetal development also provides clues as to the importance of peripheral vision. Peripheral retina develops in advance of central retina.[14] All this implies that peripheral vision is considered to be more important, or at least more basic, within the context of evolution and survival. This indicates that central vision was something of an evolutionary icing on the cake. Once the important issues of awareness for survival were taken care of, it then became possible to enable us (not only humans but other vertebrates) to inspect the details of our world now that we are safe and have some time to see the roses.

We need to know as much as possible about our surroundings for survival.[5] (p.25) But this does not necessarily relate to details; it is much more important to know the context than the particulars, at least as regards survival. Fleeing from a non-threatening intruder may be embarrassing but is safer than being unaware of its presence until it is close enough to discern the details of its appearance. Basic survival of the organism is more likely in the absence of central than in the absence of peripheral vision. While the threats to actual survival are different than they used to be, our sensory and response mechanisms are basically the same.

It is important to note that the real significance of peripheral awareness is not in the reception of information as much as it is in the response to that information. Knowing what is in our surroundings is important in the context of action for survival. While it is certainly important to know what is going on out there, it is equally important to know what needs to be done and how to go about doing it in response to what is going on out there. Peripheral vision provides humans with an early warning system and also guides our movements in response.

It must also be noted that the relationship between peripheral vision and stress is one in which the influence can go in either direction; that is, reduced peripheral awareness can increase stress just as increased stress can reduce peripheral awareness. Peripheral visual awareness also tends to ebb and flow along with various factors such as energy levels and demands of a given activity.

Peripheral Vision and Movement

Peripheral vision helps maintain optimal awareness of the total visual environment. The more aware we are of our surroundings, the easier it is to move about. The importance of this begins with eye movements themselves. Constricted peripheral awareness reduces the amount of visual information available per fixation or glance. This, in turn, reduces and disrupts the available context, which can easily decrease the quality of performance and understanding. The results of reduced peripheral awareness transfer into other areas. The less aware we are, the more likely we are to bump into things, lose track of the context in information gathering activities, and have difficulty with athletic performance. Peripheral awareness, like the whole of visual performance, is a dynamic process, not a passive act. The input is important, but the main objective is output, i.e., coming to terms with our environment via action.

Peripheral Vision and Balance

Through vision and its connections with the vestibular system,[6,15,16] we are given information about our relationship to our surroundings. This tells us if we are moving or still, if our surroundings are moving or still, or both are moving or still. This relationship can be a factor in motion sickness. The middle ear provides feedback about our posture and state of motion unless we are moving at a constant speed. The vestibular system is involved in stabilizing visual input when motion of the eyes and/or body is involved. The visual system, led by peripheral vision, also gives information about our posture and state of motion. However, unlike the vestibular system, the visual system also gives information about our state of motion at constant speeds and the status of our surroundings, i.e., the volume of space around us and the inhabitants of that space. What is it? How big is it? What distance (and therefore time) separates me from it? In which direction is it moving? What relationship does it have to my immediate circumstances? All of these types of questions can be accurately answered by well-tuned peripheral awareness.

Skeffington's Concepts in Relation to Peripheral Vision

Skeffington[17] preferred to describe vision as a dynamic process involving the organism's relationship to gravity and sense of orientation (ANTI-GRAVITY), an understanding of the volume of space within which it finds itself and other beings and objects (CENTERING), some recognition of the personal meaning of those beings and objects (IDENTIFICATION), and an ability to share all of this information with others (SPEECH/AUDITORY).

Peripheral vision's involvement with the anti-gravity process has already been touched upon. Fairly thorough information regarding "where I am" in relation to my current visual environment is provided by peripheral awareness. The more complete the visual information, the more relaxed, flexible and prepared the person is for the next move through space/time. The centering process involves one's understanding of "where it is in relation to me" and the importance of peripheral awareness is obvious. While the two foveas are designed to align on a particular object, it is the peripheral visual component that will provide the quickest and surest route to the object of interest, not to mention the fact that peripheral fusion provides a foundation for central fusion.[18-21] Actually, high-level peripheral awareness precludes the need to even look at specific objects in order to judge their spatial relationship to us. Similarly, in the identification process, peripheral vision can give us a significant amount of information about the object of interest. Through peripheral awareness we may obtain substantial data regarding identity before we even lock on with the foveas and, perhaps more importantly, we have access to a much broader context, which makes for more informed, more instantaneous, and more effortless decision making. If the speech/auditory process signifies how we relate our internal maps and concepts to others, then it will be affected by the nature of those maps and concepts. If they are constricted we may relate to others in a constricted fashion. If our perceptions are more open and free, we may be able to transmit that in our thinking, acting, and relating to others.

Effective peripheral vision/awareness is the foundation upon which an efficient, relaxed, effective visual system is based. Just as figure expresses most of its meaning within the context of its ground, so good visual information processing occurs within the context of all available information. Whether it is the selection of the most important information out of all that is available or an attempt to incorporate as

much of the available information as possible, that which is available via peripheral visual awareness is a critical guide to appropriate action and efficient utilization.

Peripheral Vision and Its Psychological Implications

"The Thalamus is ... associated with the visual pathway through the geniculate body by a GENICULO-THALAMIC TRACT. This tract has received very little attention but is of constant occurrence. The thalamus does not appear to be a link in the direct visual path, it plays by no means an inconsiderable part in the visual mechanism. In the animals below Mammalia it is that part of the brain which is responsible for the affective appreciation of experience and, therefore, in the last resort, it determines behaviour."[4] (p.250)

Peripheral vision supplies us with information about our relationship to our surroundings. It tells us where we are in relation to people, places and things in our immediate vicinity. It can provide significant information about who they are, what they are doing, and how that may affect us at that moment and in the near future. When functioning comfortably and effectively it can provide accurate information regarding size, shape, direction of movement, and even intent.

Since peripheral vision informs us of our relationship to our physical surroundings and, since vision is such an important interface between organism and environment, especially in modern culture, it is not hard to imagine this awareness/response mechanism having repercussions throughout the entire person. As peripheral awareness improves, it may effect relationships other than those with our physical surroundings. There are two possible rationales for this. One is simply the fact that when we are more aware of our immediate surroundings, there is a significant reduction in stress. This frees up our abilities to think, feel and create. The other is the transference of what may be considered strictly visual functioning into other areas of behavior.

Just as improvements achieved through vision therapy often transfer into improvements in areas such as problem solving, concentration and self-esteem, improvements in peripheral processing may transfer into more so-called peripheral aspects of our lives. For example, those close to us who are "not-me" and, therefore peripheral, may become better integrated into our awareness and behavior; relationships to one's physical environment will be less disjointed as relationships to peripheral aspects of life become more connected to each other and to ourselves. "The facts of the body both separate and connect. They testify to the links between human beings and other mammals and living systems, but they divide the sexes and the developmental stages. The body's truths are often concealed so it is not always easy to learn about birth or sex or death, or the curious and paradoxical relationships between them. We keep them separate and learn about them on different tracks, just as we learn separately about economics and medicine and art, and only peripheral vision brings them back together. Experience is structured in advance by stereotypes and idealizations, blurred by caricatures and diagrams."[22](p.5)

As our useable context expands we may proceed with better information and, very likely, more appropriate interactions. Combining this with what was previously mentioned regarding SPEECH/AUDITORY "we can take this idea further by considering the brains, bodies, and nervous systems of two people engaged in conversation. The noted American neuroscientist Eric Kandel ... has made a particularly dramatic proposal. The very fine structure of our brains and the degree of sensitivity in delicate interconnections between the nerves are not fixed, he suggests, but can actually be changed by learning. This means that when new contexts come along, the structure of our brains can respond to them. Meaning can actually modify the structure of the human brain."[23]

If this is the case, then the possibilities are wonderful. If this phenomenon occurs between individuals it must certainly be expected to occur between the various internal systems of one person. If we redefine our visual perception of context; that is, if we decide that peripheral information is not trivial, but, in fact, on at least equal footing with central information, then we are very likely starting the process of redefining this context throughout the brain.

What Can Be Done?

The enhancement of peripheral visual awareness need not be a complicated nor daunting process. As in any type of improvement or healing, the first, and probably most important, step is recognition of the issues. We are typically taught early in school that we must block out all distractions and concentrate entirely on the task at hand. We quickly learn to narrow our focus to a small volume of space/time in order to carry out our required duties. This type of behavior is not innate and, in fact, requires considerable effort to achieve. Nonetheless, with repetition this becomes an automatic behavior, one that is likely to manifest any time we are engaged in some demanding task like completing an assignment, eating a meal, or tying our shoes. If some portion of a performance is impaired, this causes the total performance to be impaired. The performer, thus impaired, must come to terms with the total environment as best s/he can. When coming to terms with the total environment is not possible, s/he will shrink the environment down to a size that can be successfully managed. This process is fairly random since few of us understand the intricacies of visual performance. Therefore the entire performance must be modified as seems to best fit the task at hand. When this is done, it happens suddenly, on an unconscious level and it is not a product of learning.[24] However, we are fortunate that our systems can experience learning. They are very plastic and prefer the path of least resistance when there are viable options—especially when achievement is relatively easy.

As previously stated, improved peripheral awareness allows for increased productivity, reduced stress and will help you prevail over your tennis buddies. Once these issues are discussed, it is fairly easy for most people to appreciate the basic concept of the benefits of increased peripheral awareness. When this occurs, a little guidance and some appropriate activities can help to start the process of increasing useable peripheral vision. There is little, if any, need for specialized training procedures to achieve the desired results. The most important concept is the changing of the context within which many activities are done. Simply put, the inclusion of frequent dialogue regarding the importance and application of peripheral awareness to any and all activity starts to break down the barriers that have been imposed both from without and from within. Those barriers cause us to believe that each task in which we engage, no

matter how simple or complex, demands our undivided attention. Certainly there are those circumstances that legitimately fall into this category, but they are not as numerous as our behavior would suggest. We must learn to better distinguish when we must close out the big picture to deal with a specific issue, and when we can and should let it all in.

I believe that one of the most important tools for enhancing peripheral processing is the use of appropriate, low plus (often no more than +0.25 or +0.50) lenses which will alter the distribution of light, increasing the stimulation of peripheral retina while reducing the emphasis on macula. Another excellent tool is binasal occlusion, which also stimulates peripheral awareness. I will typically place the tapes so they do not go past the limbus. In my experience, this gives something of a "jump start" by enhancing the peripheral fields without being as disruptive as extending the binasal occlusion to the pupillary border. In fact, I have seen some of the most exciting immediate changes in overall visual performance and comfort (in very complex cases) by extending the tapes only halfway between the inner canthus and the limbus. Both plus lenses and binasal occlusion, used in judicious ways, are geared toward causing gentle changes in the input. This in turn will cause a modification in the internal mapping process leading to improved response capabilities. While it is not at all a simple matter to maintain optimal peripheral awareness at all times, it is surprisingly easy to enhance this function enough to make a meaningful difference in overall visual performance.

In Closing ...

It seems also that the dictionary, well not the dictionary, but our utilization of it, may be part of the problem. The primary definition of peripheral is: "1. of, belonging to, or forming a periphery;" the secondary definition is "2. lying at the outside or away from the central part; outer; external." I find the most interesting definition (the tertiary, or perhaps peripheral, definition) of peripheral to be: "3. only slightly connected with what is essential or important; merely incidental; tangential."[25] After opening up to the broader context of the situation, this definition would better describe visual acuity, central vision and the typical eye exam. This is not to denigrate central vision but to emphasize the need for balance between central and peripheral in a manner more appropriate to the full scope of our lives as put forth by McDonald[26] and Wiener.[27] It has been my experience, supported by hundreds of clinical examples, that peripheral vision is the foundation upon which all other visual abilities, including visual acuity, are built. The major obstacles to increased awareness and expanded utilization of these concepts is other than clinical in nature. "Present methods to assess peripheral awareness do not allow for precise quantification. In spite of this, peripheral awareness enhancement has been used to reduce nearpoint stress, improve visual and academic performance, and in the rehabilitation of head trauma patients."[28] Although the quantification and objective measurements of this aspect of visual performance are not a simple matter, peripheral visual awareness probably deserves more of our optometric awareness. Sometimes change is directly visible, but sometimes it is apparent only to peripheral vision, altering the meaning of the foreground.[21] (p.6)

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References

1. Wiener H. Eyes OK I'm OK. San Raphael, Academic Therapy Publications, 1977: 18-25.
2. Trevarthan CB. Tow mechanisms of vision in primates. Phychol Forschung, 1968; 31: 299-337.
3. Gessell A, Ilg FL, Bullis GE. Vision: its development in infant and child. New York: Harper and Bros., 1949.
4. Duke-Elder SW. The text book of ophthalmology. St. Louis: C. V. Mosby, 1942. Vol. 1: 248.
5. Crick F. The astonishing hypothesis. New York: Charles Scribner's Sons, 1994.
6. Moses R, Ed. Adler's physiology of the eye. St. Louis, C.V. Mosby, 1981.
7. Sutton A. Building a visual space world. Optom Extension Prog. 1985; CII.(7): 43-46 and (8): 47-54
8. Witkin HA. Psychological differentiation. New York: Wiley & Sons, 1962.
9. Getman GN. Research reports and special articles: reflections. Optom Extension Prog. 1988; CII, May; 60 (8): 307-311.
10. Griffin JR. Binocular anomalies: procedures for vision therapy. Chicago, 1982.
11. Selye H. Stress without distress. New York: Signet, 1975.
12. Forrest EB. Stress and vision. Optom Extension Prog. 1988.
13. Weymouth FW, et al. Visual acuity within the area centralis and its relation to eye movements and fixation. Am J Ophthal. 1928; 11: 947.
14. Abramor I, et al. The retina of the newborn human infant. Science. 1982; July: 217.
15. Ayers AJ. Sensory integration and learning disorders. Los Angeles: Western Psychological Services, 1972.
16. Farber SD, Zoltan B. Visual vestibular systems interaction: therapeutic implications. J Head Trauma Rehabil. 1989; 4(2): 9-16.
17. Birbaum MH. Optometric management of nearpoint vision disorders. Boston: Betterworth-Heineman, 1993.
18. Burian HM, von Noorden GK. Binocular vision and ocular motility: theory and management of strabismus. St. LOuis: C. V. Mosby, 1974.
19. Beneish R, Flanders M. The role of stereopsis and early post-operative alignment in long-term surgical results of intermittent exotropia. Can J Ophthalmol. 1994; 29 (3): 119-124.
20. Kittleman WT, Mazow ML. Reoperations in esotropia surgery. An Ophthalmol. 1986; May, 18(5): 174-177.
21. Burian HM. Fusional movements, role of peripheral fusion stimuli. Arch Ophthalmol. 1939; 21: 485.
22. Bateson MC. Peripheral visions: learning along the way. New York: Harper Collins, 1994.
23. Peat FD. The philosopher's stone: chaos, synchronicity, and the hidden order of the world. New York: Bantam, 1991: 117.
24. Goldstein K. The organism. American Book Co., 1939.
25. Neufeldt V (Ed.). Webster's new world college dictionary, 3rd ed., USA: Macmillan, 1996.
26. McDonald LW. A programmed approach to visual training. Part III. Optom Extension Prog. 1962; CII, 35(3): 13-14; 52: 9-12.
27. Wiener H. Years of personal communications.
28. Marrone MA. Peripheral awareness. J Behav Optom. 1991; 2(1):11.

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